

**Remarks**

Applicant requests consideration of pending Claims 1-91 and 125-136 based on the remarks herein.

Claims 1, 20, 25, 30, 33, 36, 55, 60, 66, 72, 81, 87, 125, and 126-136 have been amended. Although Applicant considers the meaning of surface-modifying agent in the context of the claims is clearly understood by the skilled person, the claims have been amended to clarify and recite the nature of the surface-modifying agent as being capable of modifying the nitride resistive material layer (e.g., insulation layer) to enhance nitride nucleation thereon. Support for these amendments is in the specification, for example, at page 3, lines 19-21 and page 4, lines 3-5.

No new matter has been added with the amendments to the claims. The amendments are intended to merely clarify language used in the claims and the subject matter claimed, and the scope of the claims is clearly intended to be the same after the amendment as it was before the amendment.

**Information Disclosure Statements.**

The Examiner is thanked for the review of the listed references and return of the Forms PTO-1449 that have been submitted in this application.

**Rejections under 35 U.S.C. § 102 (DeBoer)**

The Examiner maintains that the previously filed response did not place the application in condition for allowance and continues her rejection of Claims 1-4, 9-10, [12]-17, 20-23, 30-31, 36-39, 41-42, 47-52, 60-62, 64, 72-74, 76, 78, 80, 125-126, 128, 130, 132 and 134 under Section 102 as anticipated by USP 6,326,277 (DeBoer). Again, this rejection is respectfully traversed.

Applicant believes that this rejection is in error because:

- 1) The Examiner has mischaracterized the disclosure of DeBoer; and
- 2) DeBoer's disclosure does not support the Examiner's rejection.

**1) The Examiner has mischaracterized the disclosure of DeBoer.**

In the Office Action at page 3, the Examiner stated (emphasis added):

Further, DeBoer discloses the method wherein the surface-modifying agent comprises... implanting at a low angle implantation of about 60-85 degrees from vertical (see column 8, lines 40-52), *the implantation implants the nitride resistive material layer within the container opening and at the corners of the container opening (see Figure 6).*

FIG. 6 is shown below.

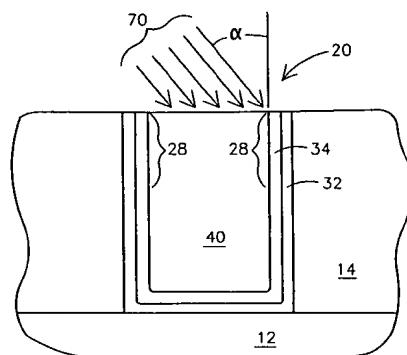


FIG. 6

DeBoer's structure (FIG. 6) has the following components:

— insulative layer 14 (described at col. 5, lines 55-65; emphasis added):

The second portion 14 of the substrate assembly 10 is preferably an insulative layer such as an oxide layer, e.g., silicon dioxide, BPSG, PSG, etc...

— conductive layer 32 (described at col. 6, lines 46-50; emphasis added):

The first layer 32 is preferably electrically conductive because it will form a portion of one electrode in a capacitor as described below. In one embodiment of the invention, the first layer 32 is formed using doped silicon, more preferably the first layer 32 consists essentially of doped silicon. The doped silicon used for the first layer 32 may be either doped amorphous silicon or doped polysilicon.

— second layer 34 which is a hemispherical grain silicon precursor layer

i.e., amorphous silicon (described at col. 7, lines 1-14 ; emphasis added):

The second layer 34 may alternately be referred to a hemispherical grain silicon precursor layer because it should be formed of materials that are amenable to the formation of hemispherical grain silicon. As a result, the second layer includes some silicon in its composition. In one embodiment of the invention, the second layer 34 is formed of undoped amorphous silicon, more preferably the second layer 34 consists essentially of undoped amorphous silicon...

The term "nitride resistive" material is defined in the specification as a material that is *unreceptive* to nitride nucleation, e.g., insulative material layer 14' — such as BPSG, oxides, etc. See specification at page 6, lines 11-13 (defined), and pages 6-7, bridging sentence:

The wafer fragment 10' is shown as comprising a substrate 12' and an overlying insulation layer 14' (i.e., nitride resistive material). Exemplary insulation materials include silicon dioxide ( $\text{SiO}_2$ ), phosphosilicate glass (PSG), borosilicate glass (BSG), and borophosphosilicate glass (BPSG), ....

By comparison, the term "nitride receptive" material in the claims is defined as a material that is *receptive* to nitride nucleation, e.g., a conductive material — such as a metal, or a semiconductive material — such as polysilicon, HSG silicon, etc. See specification at page 6, lines 9-11 (defined), and page 7, lines 3-11:

A container or opening 16' with sidewalls 24' and a bottom portion 26', has been conventionally etched into the BPSG insulation layer 14'. *The lower electrode 18' (i.e., nitride receptive material) of the capacitor comprises a semiconductive material, being HSG polysilicon in the illustrated example.* An HSG silicon electrode can be formed, for example, by converting an amorphous silicon layer deposited on the BPSG insulation layer 14' to a hemispherical grain (HSG) silicon layer....

Relative to Applicant's claims, DeBoer's structure would be as follows:

- nitride resistant layer: insulative layer 14
- nitride receptive layer: *second (amorphous silicon) layer 34*<sup>1</sup>

Thus, the Examiners statement that "the implantation implants the nitride resistive material layer within the container opening and at the corners of the container opening," with reference to FIG. 6, is clearly erroneous. The material within the container opening and at the corners of the container opening is the *second (amorphous silicon) layer 34* — a nitride receptive material layer.

As recited in the claims, the method involves implanting an agent into exposed surfaces of the nitride resistive material layer — e.g.,  $\text{SiO}_2$ , PSG, BSG, BPSG, etc.

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<sup>1</sup> DeBoer refers to several patents providing techniques for formation of HSG silicon (see col. 9, lines 11-24). HSG silicon is formed by subjecting amorphous silicon (deposited from dichlorosilane, disilane or trisilane) to an annealing step at elevated temperatures to transform it into a hemispherical grain silicon.

**2) DeBoer's disclosure does not support the Examiner's rejection.**

In the final Office Action at page 6, the Examiner now asserts that DeBoer discloses implanting a nitride resistive material layer (14, of BPSG):

It is clear to the examiner that the nitride resistive material (14, of BPSG) is implanted absent a mask. The examiner notes that the disclosure does not mention a mask being utilized during the implantation step of DeBoer.

The Examiner's assertion is in error.

DeBoer specifically teaches selectively doping an edge portion of an HSG silicon precursor layer. See, for example, the Abstract (emphasis added):

**Abstract**

Methods of manufacturing capacitor structure with edge zones that are substantially free of hemispherical grain silicon along the upper edges of the capacitor structures a disclosed. ... Among the methods of the present invention are methods of forming the capacitor structures in which the silicon layer used to form the hemispherical grain silicon is selectively doped. That selective doping provides an edge zone that does not convert to hemispherical gain silicon during manufacturing.

This teaching of selective doping is repeated throughout the Summary (see col. 2, lines 16-38; (emphasis added):

**SUMMARY OF THE INVENTION**

.... Among the methods of the present invention are methods of forming the capacitor structures in which the silicon layer used to form the hemispherical grain silicon is selectively doped. That selective doping provides an edge zone that does not convert to hemispherical grain silicon during manufacturing.

In one aspect, the present invention provides a method of forming a capacitor structure by: ...providing a second layer on substantially all of the first layer, the second layer including hemispherical grain silicon precursor; selectively doping the hemispherical grain silicon precursor in the second layer within an edge zone on the sidewall structure, the edge zone extending from the opening of the cavity towards the bottom of the cavity; ...

Further, referring to FIG. 6 (above), the Detailed Description of DeBoer describes the implantation process step as follows (see col. 7, lines 40-50 emphasis added):

After removal of the first layer 32, second layer 34 and the fill material 40 (if any) from the areas outside of the cavity 20, an edge 33 of the first layer 32 and an edge 35 of the second layer 34 are exposed about the upper perimeter of the cavity 20 as illustrated in FIG. 5. That structure can then be subjected to an ion implantation process in which an upper portion, referred to herein as an edge zone 28, of the second layer 34 is implanted with an N-type dopant, P-type dopant, or other species such as oxygen or nitrogen that can prevent conversion of the hemispherical grain silicon precursor in the second layer 34 to hemispherical grain silicon.

The *selective doping* of the amorphous silicon (HSG precursor) layer 34 is again stated by DeBoer at col. 8, lines 59-60 (emphasis added):

*Following selective doping of the portion of the second layer 34 in the edge zone 28, the fill material (if any) within the cavity 20 can be removed by any suitable technique.*

Clearly, DeBoer does not teach or suggest implanting a surface modifying agent into the insulative layer 14. DeBoer specifically teaches *targeted implantation* which is *limited to the edge zone 28 of the amorphous silicon layer 34* — within the container opening and at the corners of the container opening.

DeBoer thus teaches limiting the ion implantation to a nitride *receptive* material layer — the amorphous silicon (HSG precursor) layer 34.

DeBoer's targeted doping of a nitride receptive material layer — amorphous silicon (HSG silicon precursor) — does not teach or suggest implanting a surface-modifying agent into a nitride resistive material layer, as claimed by Applicant.

Furthermore, DeBoer does not teach or suggest implantation of a material that will modify the surface of a nitride resistive layer — e.g., insulative material layer.<sup>2</sup>

Rather, DeBoer teaches implanting a dopant material *that functions to modify the amorphous silicon layer 14* — a nitride *receptive* layer — to prevent conversion of amorphous silicon (HSG silicon precursor) to HSG silicon during subsequent processing steps (see at col. 7, lines 44-56; emphasis added):

After removal of ... That structure can then be subjected to an ion implantation process in which an upper portion, referred to herein as an edge zone 28, of the second layer 34 is implanted with an N-type dopant, P-type dopant, or other species such as oxygen or nitrogen *that can prevent conversion of the hemispherical grain silicon precursor in the second layer 34 to hemispherical grain silicon.*

The dopant is implanted at a concentration level that substantially reduces, more preferably substantially prevents, formation of hemispherical grain silicon from the second layer 34 in the edge zone 28. In other words, the silicon in the second layer 34 within the edge zone 28 no longer functions as a "hemispherical grain silicon precursor" as described above.

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<sup>2</sup> The claims have been amended to clarify that the surface-modifying agent is capable of modifying the surface of the nitride resistive material to enhance nitride nucleation thereon.

The modifying agent of DeBoer functions to modify amorphous silicon — a nitride *receptive* layer. DeBoer does not disclose a modifying agent that functions to modify the surface of a nitride *resistive* layer — e.g., insulative material, as recited in the claims.

DeBoer does not teach the elements of Applicant's method as claimed. In particular, DeBoer does not disclose implanting an agent into exposed surfaces of a nitride *resistive* material layer, nor a surface-modifying agent that functions to modify the surface of a nitride *resistive* layer.

Accordingly, withdrawal of this rejection is respectfully requested.

#### **Rejections under 35 U.S.C. §103(a) (DeBoer as primary reference)**

The Examiner also continues her rejection of Claims 11, 40 and 65 under Section 103(a) as obvious over DeBoer; Claims 5 and 43 as obvious over DeBoer in view of USP 5,783,469 (Gardner); and Claims 55-58, 63, 75, 81-83, 85, 87-88, 90, 131 and 135-136 as obvious over DeBoer in view of USP 5,118,636 (Hosaka). Again, these rejections are respectfully traversed.

With respect to Claims 11, 40 and 65, the Examiner previously asserted that, although not disclosed by DeBoer, the selection of the implantation dosage would be obvious as a matter of determining an optimum process condition.

DeBoer is limited to a disclosure of the concentration level of an agent that modifies *amorphous silicon* (nitride *receptive*) to prevent its conversion to HSG silicon (col. 7, lines 39-49; emphasis added):

After removal of the first layer 32, second layer 34... That structure can then be subjected to an ion implantation process in which an upper portion, referred to herein as an edge zone 28, of the second layer 34 is implanted with an N-type dopant, P-type dopant, or other species such as oxygen or nitrogen that can prevent conversion of the hemispherical grain silicon precursor in the second layer 34 to hemispherical grain silicon.

The dopant is implanted at a concentration level that substantially reduces, more preferably substantially prevents, formation of hemispherical grain silicon from the second layer 34 in the edge zone 28. In other words, the silicon in the second layer 34 within the edge zone 28 no longer functions as a "hemispherical grain silicon precursor" as described above.

DeBoer provides no information on a surface-modifying agent that functions to modify the surface of the nitride resistive material (e.g., insulative layer) to enhance nitride nucleation thereon. Nor does DeBoer provide any information on the concentration amount of such a surface-modifying agent such that, when implanted into both a nitride receptive layer (e.g., silicon) and a nitride resistive layer (e.g., BPSG), a dielectric layer subsequently formed over both material types has a uniform thickness.

Accordingly, withdrawal of the rejection of Claims 11, 40 and 65 is respectfully requested.

With respect to Claims 5 and 43, the Examiner previously asserted that, although DeBoer does not disclose trifluoronitride ( $NF_3$ ) as a surface-modifying agent, Gardner teaches that nitrogen and trifluoronitride are art recognized equivalents as implant gases.

Gardner teaches introducing nitrogen-bearing impurities *into a conductive gate layer* (i.e., heavily doped *polysilicon*) and an *underlying* gate dielectric layer to improve the bond structure of the polysilicon gate—oxide interface so as to inhibit diffusion of boron through the interface into an underlying active region.

Gardner's process of introducing nitrogen-bearing impurities is described at col. 5, line 62 to col. 6, line 8 — referring to FIG. 3 below:

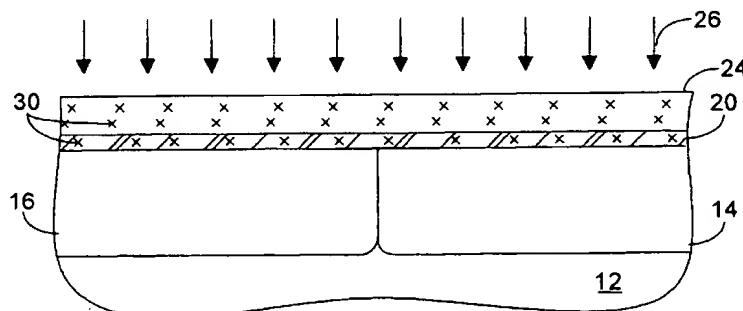


FIG. 3

...FIG. 3 further shows the introduction of a nitrogen bearing impurity distribution 30 into conductive gate layer 24 and dielectric layer 20 through the use of ion implant 26. ...the implant dose and energy are adjusted such that the a peak nitrogen concentration within conductive layer 24 is proximal ... the interface between gate dielectric 20 and conductive gate layer 24 ...

Relative to Applicant's claims, Gardner's structure is as follows:

- conductive gate (polysilicon<sup>3</sup>) layer 24: nitride *receptive* layer
- dielectric layer 20: nitride *resistant* layer

Garner does not teach implanting an agent into exposed surfaces of the nitride resistive (dielectric) material. Gardner teaches introducing an impurity into a structure having an upper conductive (nitride receptive) layer and an underlying dielectric (nitride resistant) layer.

Further, Garner does not teach implanting an agent *to modify the surface* of a nitride *resistant* (dielectric) layer *to enhance nitride nucleation thereon* (as recited in the claims). With Gardner's process, a conductive layer overlies the surface of the dielectric layer 20 when the step of introducing the impurity is performed *to alter the interface* between the conductive layer and the dielectric layer.

Thus, Gardner does not teach an agent that functions to modify the surface of a nitride resistive layer for enhanced nitride nucleation thereon. Gardner teaches an agent that functions to modify the interface between the conductive gate layer 24 and the underlying dielectric layer 20 to prevent diffusion of impurities from the gate into the active regions through the gate dielectric. See Gardner at col. 7, lines 1-12 (emphasis added):

...the process sequence described in FIGS. 1-6 is capable of producing an integrated circuit useful in *preventing the diffusion of impurities from the gate structures into the active regions through the gate dielectric*. It will be still further appreciated that by incorporating nitrogen into the source/drain regions, the active current is increased without substantially increasing the leakage current. It will be still further appreciated that because *the nitrogenated gate regions tend to form stronger bonds with the underlying gate dielectric, that the quality of the polysilicon-SiO<sub>2</sub> interface is improved*.

Combining Gardner's disclosure of the use of NF<sub>3</sub> as an implant gas into a conductive layer 24 — with DeBoer's disclosure of implanting an agent to modify the surface of an amorphous silicon layer 34 — both such layers being nitride *receptive* not nitride *resistive* as required by Applicant's claims — does not obviate Applicant's methods as claimed.

DeBoer, either alone or combined with Gardner, does not teach or suggest Applicant's method as claimed. Accordingly, withdrawal of the rejection of Claims 5 and 43 is respectfully requested.

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<sup>3</sup> See Gardner at col. 5, lines 55-65: "...In the presently preferred embodiment, conductive gate layer 24 comprises heavily doped polysilicon. In alternative embodiments...conductive gate layer 24 may be comprise of a composite including polysilicon, aluminum, tungsten, titanium, or other suitable conducting material..."

With respect to Claims 55-58, 63, 75, 81-83, 85, 87-88, 90, 131 and 135-136, the Examiner previously asserted that, although DeBoer does not disclose rotating the substrate during the implantation step, it would be obvious to modify DeBoer's method to rotate the substrate during implantation based on Hosaka in order to prevent a shadowing effect.

In the final Office Action at pages 6-7, the Examiner further asserts that (emphasis added):

...The examiner notes that DeBoer is concerned with having all of the top portions of the edge of the cavity to be implanted so that the HSG would not form on all of the top portions of HSG. In other words, **DeBoer also would like to avoid the shadowing effect** caused by the angle of the implant, and thus, rotation of the substrate would be desired.

...Hosaka teaches that the rotation allows for prevention of the shadowing effect.

The Examiner's statement is in error.

FIG. 6 of DeBoer depicts the implantation process step.

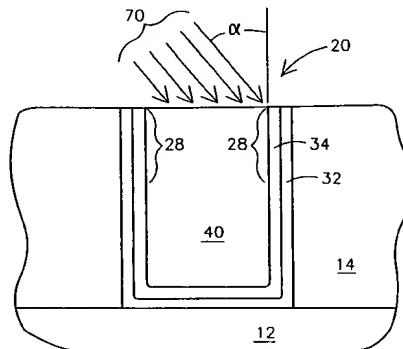


FIG. 6

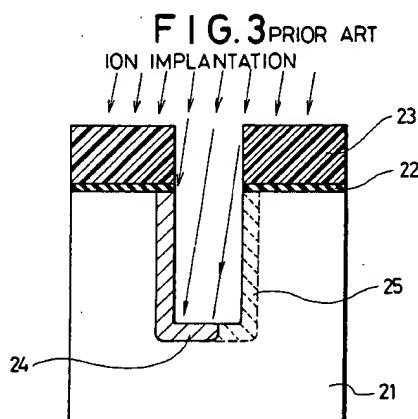
DeBoer does not teach avoiding a shadowing effect. To the contrary, DeBoer specifically teaches using a shadowing effect to avoid implanting dopant below the edge zone 28. To that end, DeBoer teaches implanting dopant at an angle greater than zero — **such that there will be a shadowing effect** (col. 8, lines 42-52; emphasis added):

...By directing the dopant ions 70 at an implantation angle  $\alpha$  that is greater than zero, preferably about 5 degrees or more, and more preferably about 45 degrees or more, the lower portions of the second layer 34 within the cavity 20 will be protected from dopant implantation by shadowing of the opposite side of the cavity 20. Those undoped portions of the hemispherical grain silicon precursor in the second layer 34 below the edge zone 28 remain convertible to hemispherical grain silicon, while the doped portions in the edge zone 28 do not convert to hemispherical grain silicon.

As stated in Hosaka, the results of a "shadowing effect" is that a portion 25 of an opening is not implanted with ions (col. 1, lines 27-37):

...However, when a trench is deep, *a part of the trench is not implanted with ions*. As shown in FIG. 3, because the incident angle of ions for ion implantation is adjusted at 7° in order to prevent the channeling phenomenon, ions are consequently blocked by a masking resist 23 during ion implantation, which phenomenon is called the shadowing effect, and a part 25 of the trench is not implanted with ions.

*The rotating ion implantation method is used in order to prevent the shadowing effect...*



Thus, Hosaka discloses *rotating* the substrate to ion implant the entire depth of the opening.

This is contrary to DeBoer's disclosure and method. DeBoer is directed to implanting only the upper portion of an opening — not the entire depth. DeBoer specifically teaches selective doping of the amorphous silicon layer that is limited to the edge portion 28 of the amorphous silicon layer.

Thus, based on Hosaka's teaching that rotating the substrate avoids a shadowing effect such that the entire depth of an opening is implanted — and DeBoer's contrary teaching to utilize a shadowing effect so that only the upper zone 28 of an opening is implanted and not the entire depth, there is no motivation to alter DeBoer's method to include rotating the substrate.

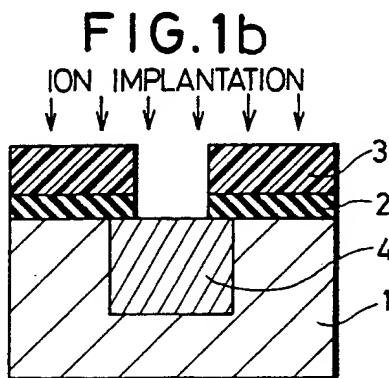
The Examiner's reliance on Hosaka for the rejection of Claims 55-58, 63, 75, 81-83, 85, 87-88, 90, 131 and 135-136 is clearly erroneous and without basis.

With respect to Claim 57, the Examiner previously asserted that, although not disclosed by DeBoer or Hosaka, the selection of the implantation dosage would be obvious as a matter of determining an optimum process condition.

As stated above, DeBoer is limited to a disclosure of the concentration level of an agent that modifies *amorphous silicon* (nitride receptive) to prevent its conversion to HSG silicon.<sup>4</sup>

Likewise, Hosaka teaches implantation of a semiconductor substrate 1 (e.g., silicon) — a nitride *receptive* material, as described at col. 2, lines 35-42 (emphasis added), and shown below in FIG. 1b.

As shown in FIG. 1(b), using a high energy ion implantation apparatus, *the semiconductor substrate 1 is ion implanted* at the window with impurity ions such as phosphorous (P), arsenic (As), antimony (Sb), boron (B), etc. In this ion implantation method, *the semiconductor substrate 1 is implanted* with ions from its surface to a depth adjacent to the bottom of a trench to be formed later....



Neither DeBoer nor Hosaka provide any information on a surface modifying agent that functions to modify the surface of a nitride resistive material (e.g., insulative layer) to enhance nitride nucleation thereon. Nor do these references provide any information on the concentration amount of such a surface modifying agent such that, when implanted into a nitride resistive layer (e.g., BPSG), a dielectric layer subsequently formed over the implanted nitride resistive layer and a nitride receptive layer (e.g., silicon) has a uniform thickness.

Accordingly, withdrawal of the rejection of Claim 57 is respectfully requested.

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<sup>4</sup> See DeBoer col. 7, lines 39-49; emphasis added: "...an upper portion, referred to herein as an edge zone 28, of the second layer 34 is implanted with an N-type dopant, P-type dopant, or other species ...*that can prevent conversion of the hemispherical grain silicon precursor in the second layer 34 to hemispherical grain silicon*."

Accordingly, withdrawal of the rejection of Claim 57 is respectfully requested.

None of the cited references, either alone or in combination, teach or suggest Applicant's methods as claimed. Accordingly, withdrawal of these rejections is respectfully requested.

**Extension of Term.** The proceedings herein are for a patent application and the provisions of 37 CFR § 1.136 apply. Applicant believes that no extension of term is required. However, this conditional petition is being made to provide for the possibility that Applicant has inadvertently overlooked the need for a petition for extension of time.

Based on the above remarks, the Examiner is respectfully requested to reconsider and withdraw the rejections of the claims. It is submitted that the present claims are in condition for allowance, and notification to that effect is respectfully requested.

Respectfully submitted,

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